United States Patent [19]

Storm et al.

[11] **3,805,902**

[45] **Apr. 23, 1974**

[54] **WELL DRILLING APPARATUS AND METHOD**

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[22] Filed: **Mar. 26, 1973**

[21] Appl. No.: **344,516**

[52] **U.S. Cl.** **175/85,** 214/2.5, 175/5

[51] **Int. Cl.** **E21b 19/00**

[58] **Field of Search** 175/85, 98, 5; 166/.5, 166/.6; 214/2.5

[56] **References Cited**

UNITED STATES PATENTS

3,443,647	5/1969	Jenkins et al.	175/85
3,451,493	6/1969	Storm	175/9
3,464,507	9/1969	Alexander et al.	175/85
3,561,616	2/1971	Eddy et al.	175/85
3,650,339	3/1972	Selfe et al.	175/85

Primary Examiner—Henry C. Sutherland
Assistant Examiner—Richard E. Favreau
Attorney, Agent, or Firm—Jack Schuman

[57] **ABSTRACT**

Drilling apparatus is shown comprising a slant hole drilling derrick and a vertical pipe racking tower facing the open end of the derrick. A pivoted cup is provided at one side of the rotary table and is adapted to receive the lower end of a stand of drill pipe. A counterweighted forked cable arrangement is provided between the upper end of the derrick and the upper end of the vertical pipe racking tower, the forked cable being adapted to be secured to the upper end of a stand of drill pipe to transfer the said stand of drill pipe between the derrick and the vertical pipe racking tower. A plurality of hinged, power-operated centering devices are mounted on the derrick to engage the stand of drill pipe at various points along the length thereof. A sliding stabbing finger is provided at the upper end of the derrick to hold a stand of drill pipe out of the central portion of the derrick during part of the transfer operation of the said stand of drill pipe between the derrick and the vertical pipe racking tower. The foregoing features are operated in a coordinated manner to facilitate and expedite the handling of stands of drill pipe.

26 Claims, 15 Drawing Figures

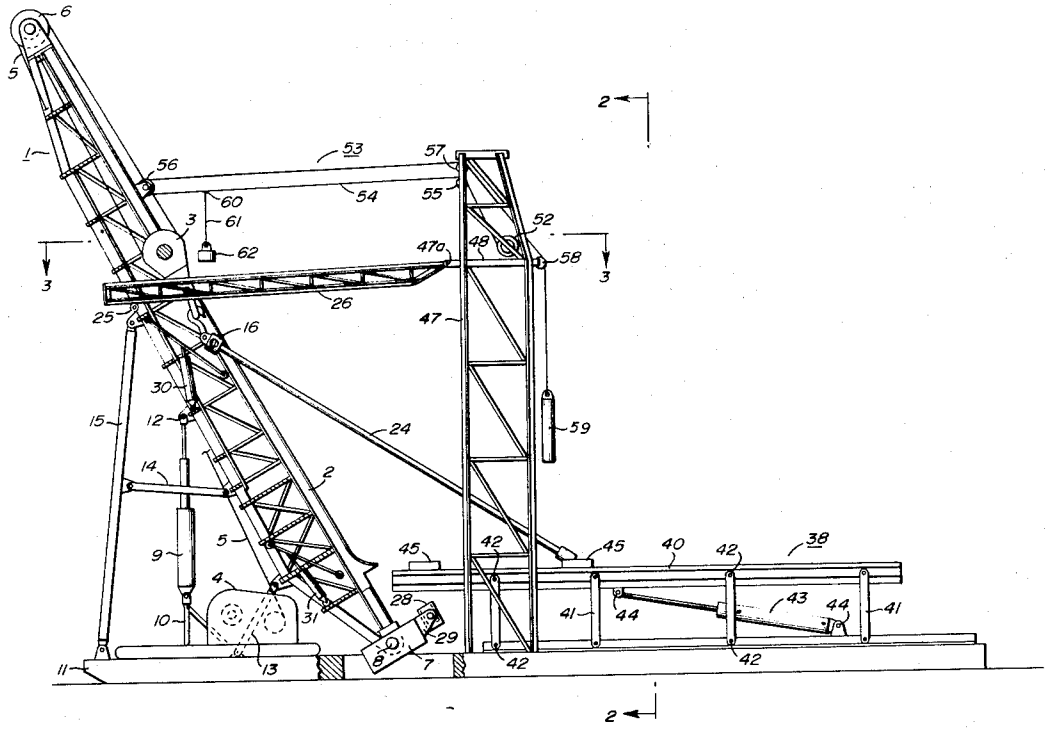


Fig. 2

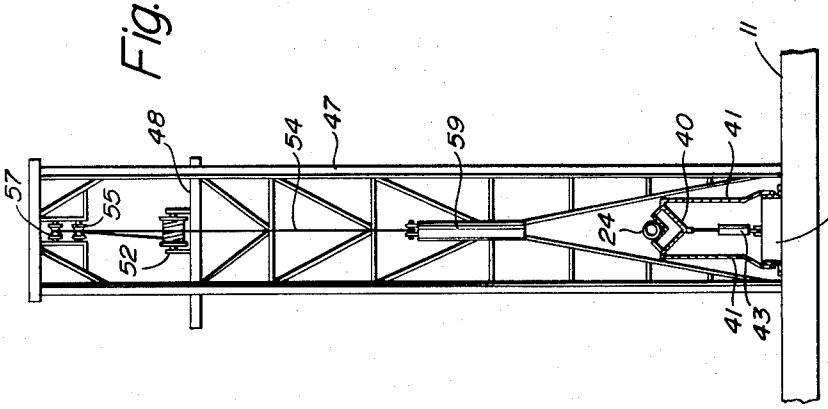


Fig. 1

Fig. 4

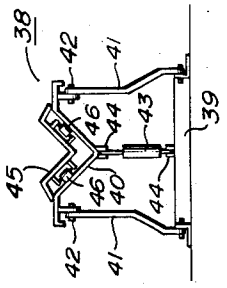


Fig. 7

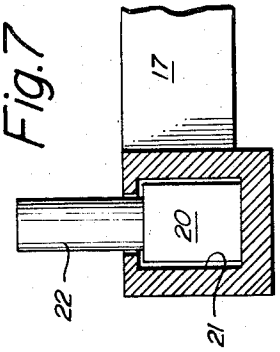


Fig. 8

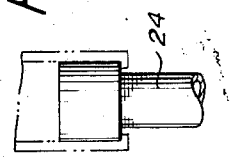


Fig. 3

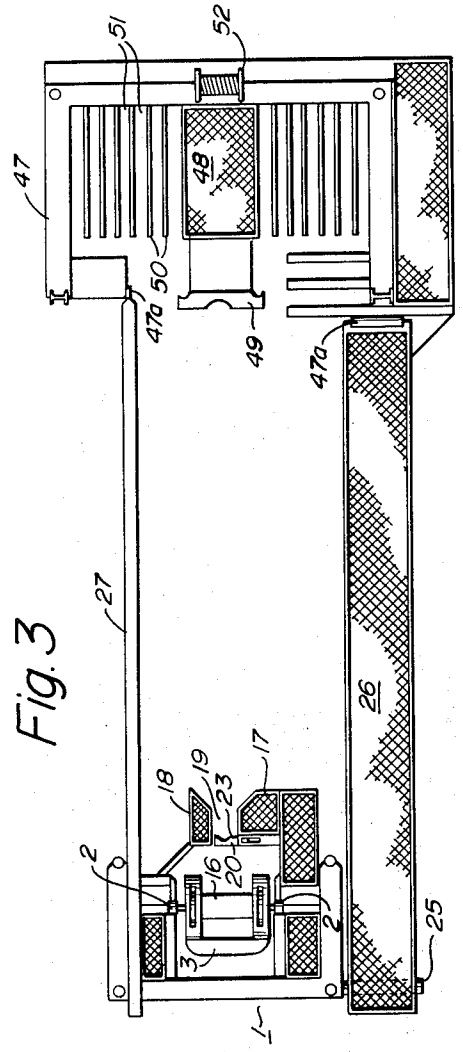


Fig. 6

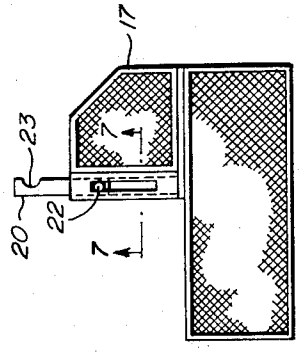


Fig. 5

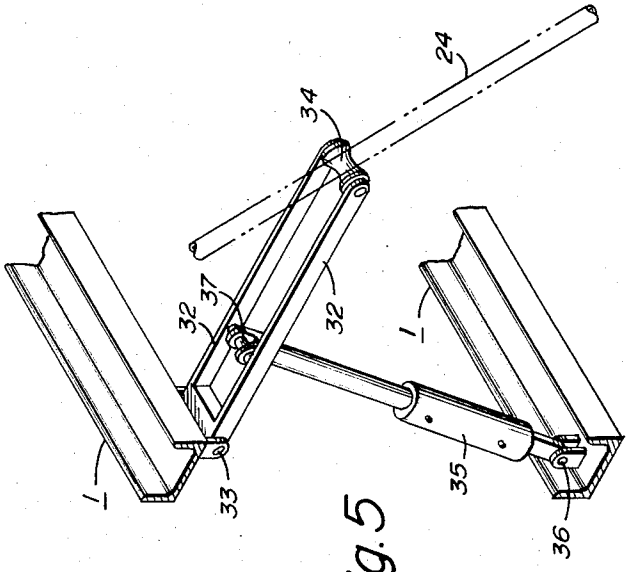


Fig. 10

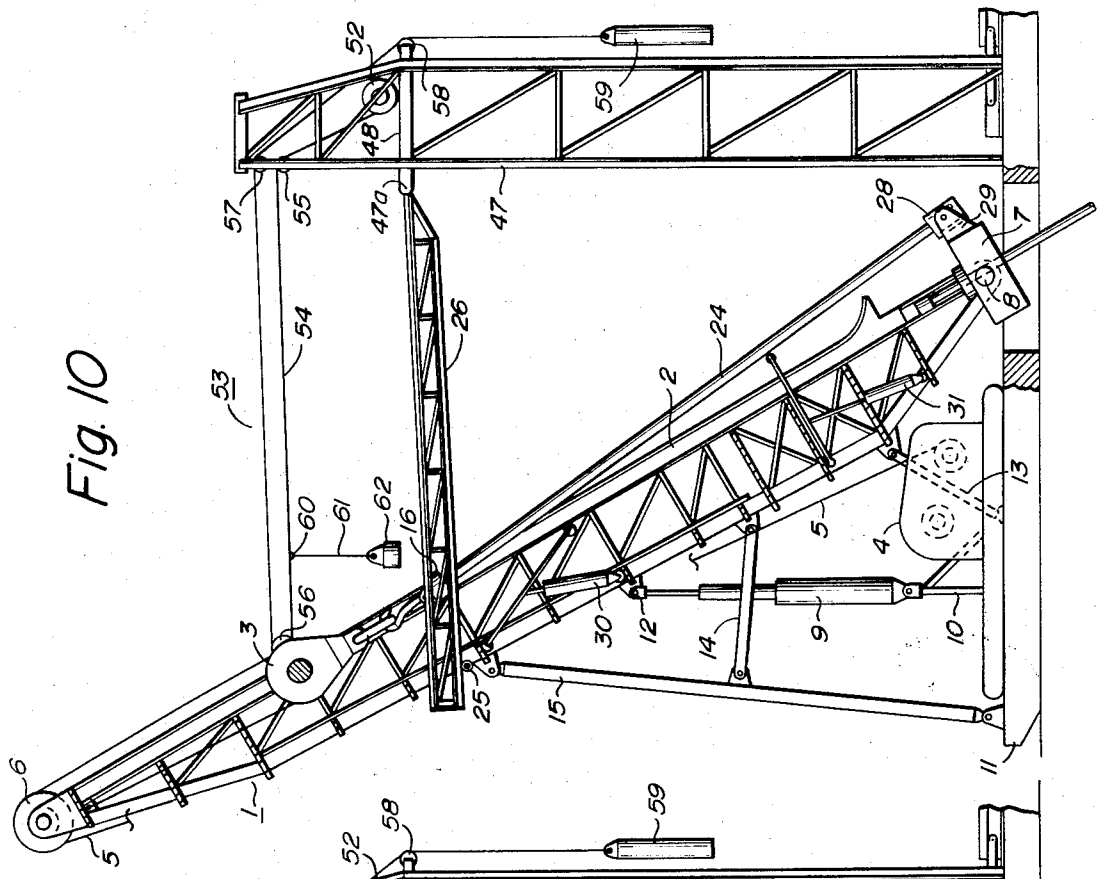


Fig. 9

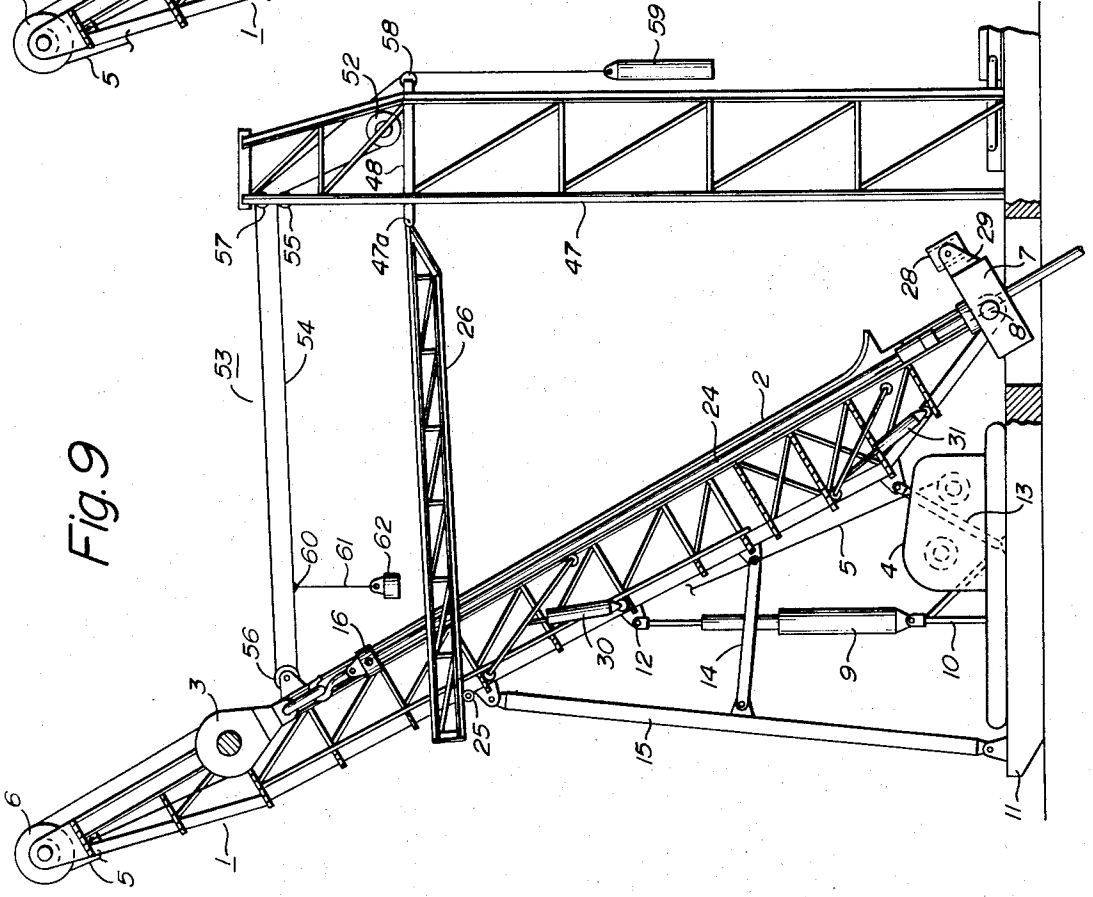


Fig. 12

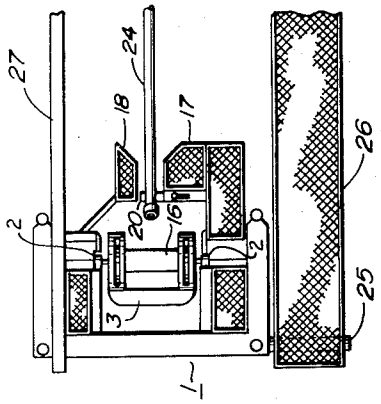


Fig. 14

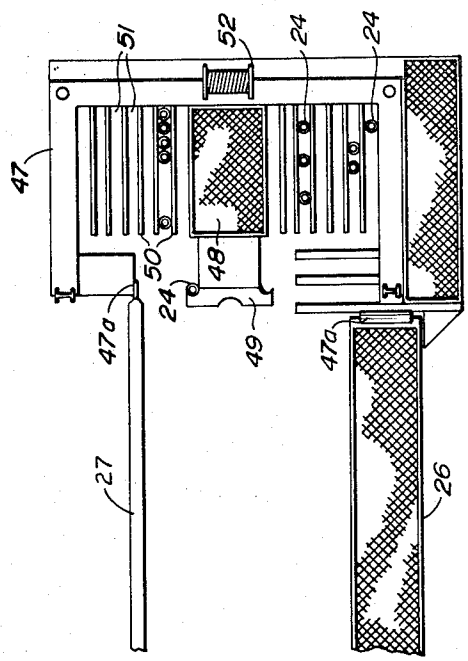


Fig. 11

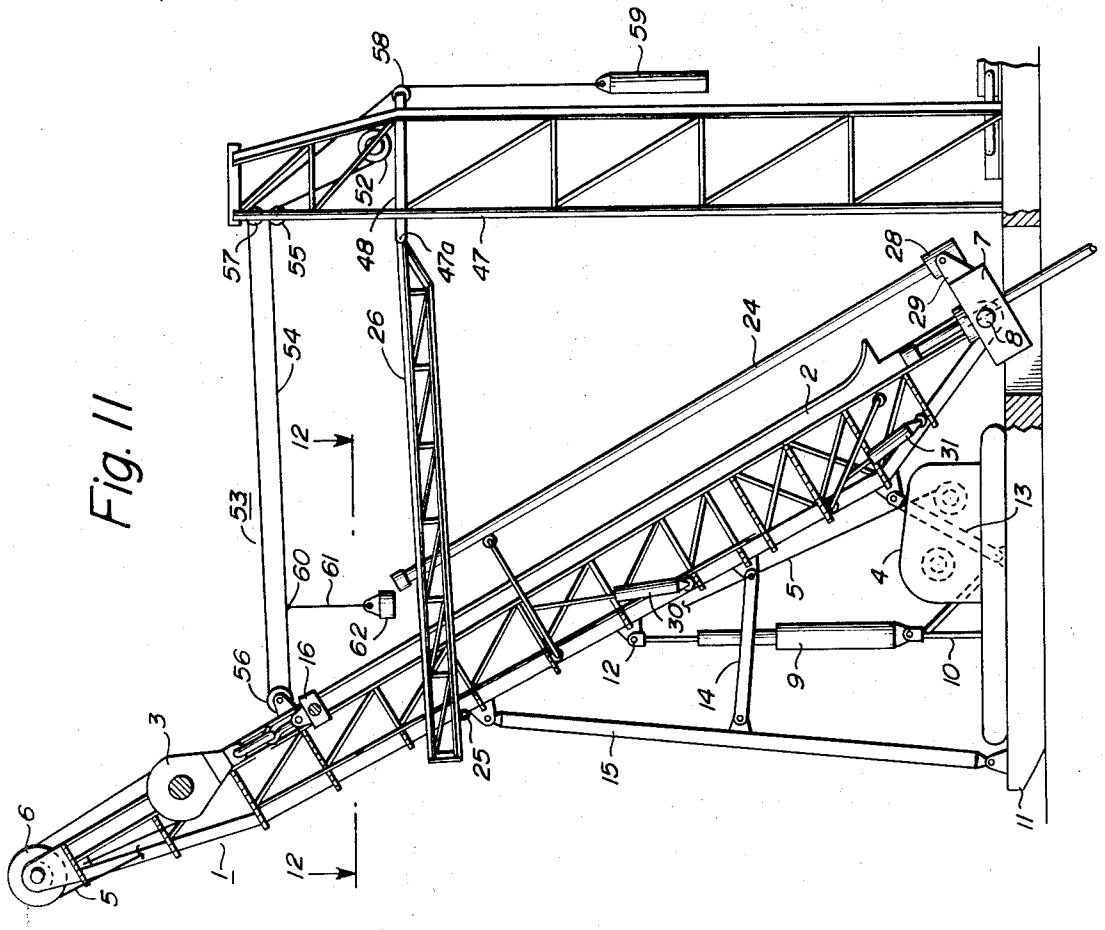


Fig. 15

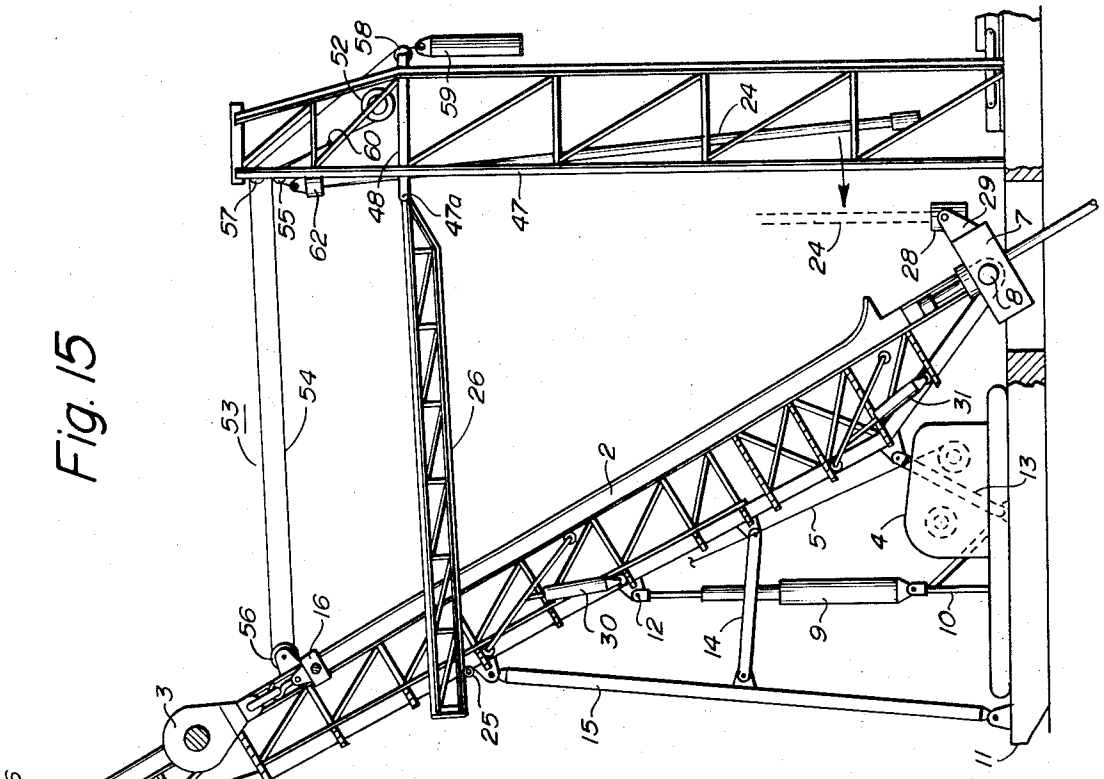
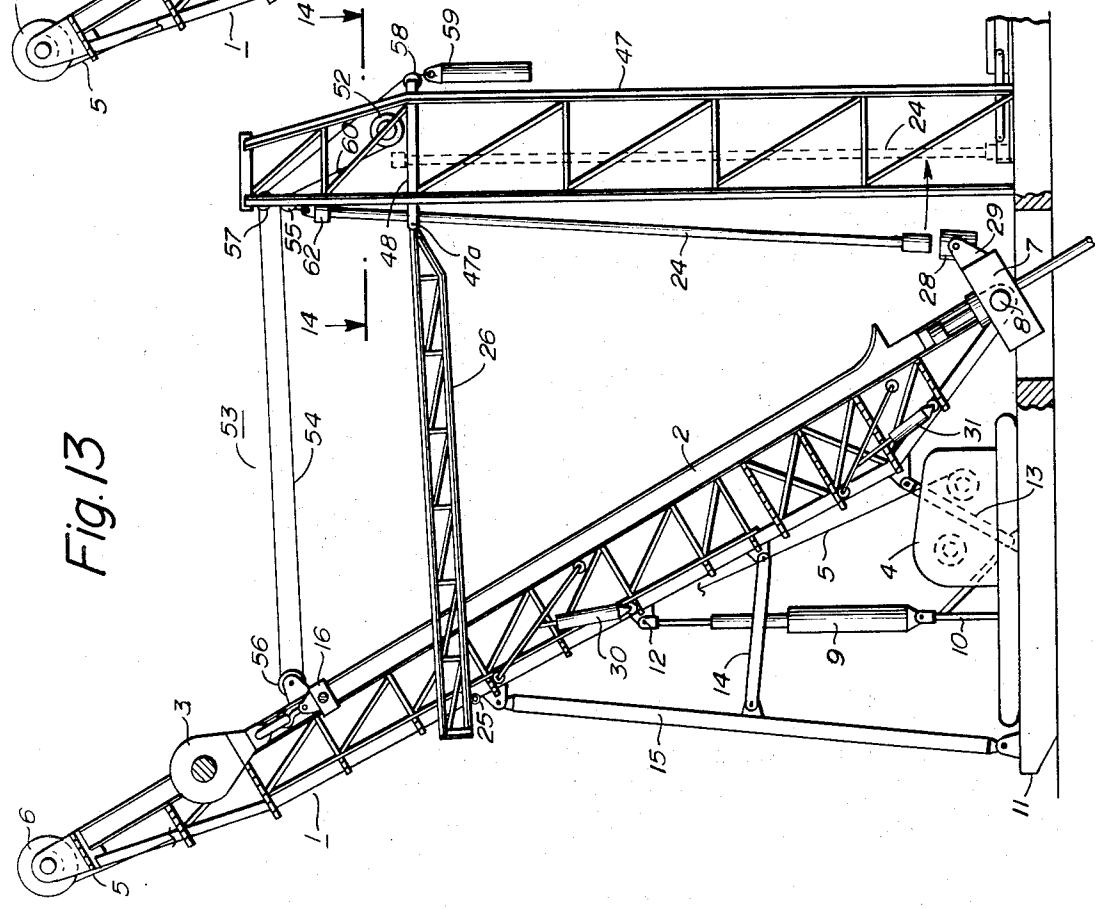


Fig. 13



WELL DRILLING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates, broadly speaking, to apparatus and method for well drilling. More specifically, this invention relates to well drilling apparatus and method with improved handling of stands of drill pipe between a slant hole drilling derrick and a vertical pipe racking tower.

2. Description of the Prior Art:

In U.S. Pat. No. 3,451,493 (1969) to Storm, an eminently practical slant hole drilling derrick is shown in association with a horizontal pipe laydown device for handling stands of drill pipe between trips (i.e., as the drill pipe is removed from a well and from the slant hole drilling derrick or, conversely, for bringing stands of drill pipe to the slant hole drilling derrick for insertion in the well).

In U.S. Pat. No. 3,443,647 (1969) to Jenkins et al., a vertical pipe racking tower for handling stands of drill pipe associated with a slant hole drilling derrick is shown. The lower end of a stand of drill pipe is supported by a catline and is swung from the rotary to the racking tower, and the upper end of the stand of drill pipe is swung from the slant hole drilling derrick to the racking tower by another line. This arrangement is cumbersome and leaves something to be desired in the course of operation.

In U.S. Pat. No. 3,561,616 (1971) to Eddy et al., and in U.S. Pat. No. 3,650,339 (1972) to Selfe et al., a vertical racking tower for handling stands of drill pipe associated with a slant hole drilling derrick is shown. Tracks are provided between the derrick and the racking tower, and a trolley carrying a pipe elevator runs on the tracks. Both of these patents show means for engaging the lower portion of a stand of drill pipe during transfer thereof between the derrick and the racking tower.

The present invention represents an improvement over the methods and apparatus of the prior art patents.

SUMMARY OF THE INVENTION

One of the objects of this invention is to provide improved apparatus and method for well drilling.

Another of the objects of this invention is to provide improved apparatus and method for handling stands of drill pipe used in slant hole drilling derricks.

Other and further objects of this invention will become apparent during the course of the following description and by reference to the accompanying drawings and the appended claims.

Briefly, we have discovered that the foregoing objects may be attained by providing adjacent a slant hole drilling derrick and facing the open side thereof a vertical pipe racking tower, by providing a pivoted cup at one side of the rotary table adapted to receive and support the lower end of a stand of drill pipe, by providing a counterweighted forked cable arrangement adapted to be clamped to the upper end of a stand of drill pipe to swing the same between the slanted derrick and the racking tower, by providing a plurality of hinged, power-operated centering devices on the slanting derrick and adapted to engage the stand of drill pipe at various points, by providing a sliding stabbing finger at the derrick to hold the upper end of a stand of drill pipe out of the central portion of the derrick, and by operating all of the foregoing features in a coordinated manner to facilitate and expedite the handling of stands of drill pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, in which like numerals represent like parts in the several views:

FIG. **1** represents a side elevation of a slant hole drilling derrick, vertical pipe racking tower and horizontal pipe laydown device, showing in an initial stage of operation a stand of drill pipe in the act of being transferred from the horizontal pipe laydown device through the lower end of the vertical racking tower to the slanted derrick.

FIG. **2** represents an elevation of the vertical pipe racking tower and the horizontal pipe laydown device as viewed along the line **2—2** of FIG. **1.**

FIG. **3** represents a plan view, partially in section, taken along the line **3—3** of FIG. **1.**

FIG. **4** represents a view in end elevation of the horizontal pipe laydown device in extended position.

FIG. **5** represents a perspective view of a typical centering device in extended position, with the drill pipe shown in phantom.

FIG. **6** represents a view in plan of the sliding stabbing finger in extended position.

FIG. **7** represents an enlarged transverse section of the sliding stabbing finger taken along the line **7—7** of FIG. **6.**

FIG. **8** represents a view in elevation of the upper end of a stand of drill pipe showing the enlarged socket or tool joint in which a female thread is provided, and further showing in phantom and diagrammatically the outline of the pipe elevator which clamps around and under the socket or tool joint whereby the stand of drill pipe may be elevated or lowered.

FIG. **9** represents a side elevation of the slant hole drilling derrick and the vertical pipe racking tower, with the drill pipe elevated in the derrick by the travelling block so that the tool joint to be broken or made up is just above the rotary table, the upper and lower centering devices being retracted.

FIG. **10** represents a side elevation of the slant hole drilling derrick and the vertical pipe racking tower, with the tool joint immediately above the rotary table broken and the lower centering device extended to swing the lower end of the stand of drill pipe away from the derrick, the bottom end of the stand of drill pipe being shown in the pivoted support cup mounted on the side of the rotary table.

FIG. **11** represents a side elevation of the slant hole drilling derrick and the vertical pipe racking tower, showing the upper centering device extended to swing the upper end of the stand of drill pipe out of the derrick and beyond the sliding stabbing finger, the bottom end of the stand of drill pipe being shown in the pivoted support cup mounted on the side of the rotary table, and the lower centering device being retracted.

FIG. **12** represents a view, partially in section, taken along the line **12—12** of FIG. **11,** of the derrick man's platform, showing the sliding stabbing finger extended and supporting out of the derrick the upper end of a stand of drill pipe.

FIG. **13** represents a side elevation of the slant hole drilling derrick and the vertical pipe racking tower,

showing the counter-weighted forked cable carrying the pipe transfer elevator and the stand of drill pipe secured thereto to the vertical pipe racking tower, the stand of drill pipe being lifted out of the pivoted support cup.

FIG. 14 represents a view in plan taken along the line 14—14 of FIG. 13, partially in section, showing the operating platform on the vertical pipe racking tower.

FIG. 15 represents a side elevation of the slant hole drilling derrick and the vertical pipe racking tower, with a stand of drill pipe being lifted from the vertical pipe racking tower by the forked cable arrangement, and the bottom of the stand of drill pipe being swung over and into the pivoted support cup preparatory to being transferred to the slant hole drilling derrick.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Slant hole drilling derrick **1**, similar in construction and operation to the derrick shown in U.S. Pat. No. 3,451,493 (1969) to Storm, has an open side bounded by inwardly facing channels **2** providing trackways lengthwise of the derrick **1** for travelling block **3**. Draw works **4**, through line **5** and crown block **6**, raises or selectively lowers the travelling block **3**.

Derrick **1** and rotary table **7** are pivotally mounted about axis **8**, for the purposes described in U.S. Pat. No. 3,451,493. Hydraulic rams **9** are pivotally supported each on leg **10** secured to skid unit **11**, and the top of each hydraulic ram **9** is pivotally secured at **12** to one of the rear main structural elements of derrick **1**. It will be apparent that, when hydraulic ram **9** is operated by a conventional hydraulic system (not shown), the angle of inclination of derrick **1** may be adjusted as required to drill a well hole at a desired angle. Various stiff legs or braces **13, 14** and **15**, adjustable or non-adjustable depending upon whether or not derrick **1** is to be operated at only one or at several different angles of inclination, may be secured to the skid unit **11** and derrick **1** after the said derrick **1** has been tilted to the desired inclination, to permit hydraulic ram **9** to be relieved of hydraulic pressure therein if desired.

Guy lines (not shown) may be employed, extending between the skid unit **11** and the top of derrick **1** thereby to brace the said derrick **1**.

It will, of course, be understood that in normal drilling operations, the conventional swivel and kelly are suspended from the travelling block **3** and are raised or lowered thereby. Inasmuch as the present invention is particularly directed to the handling of stands of drill pipe between the derrick **1** and storage when making a trip (that is to say, when the drill pipe is removed from the well and broken down into stands for storage in order to reach and replace a worn or broken drill bit at the bottom of the string of drill pipe in the well and, after replacement of the drill bit, when the stands of drill pipe from storage are reassembled into a string of drill pipe and reinserted into the well), there is no need to show or further describe in this application the conventional swivel and the kelly.

Rather, when the drill pipe is to be removed from the well and reinserted into the well in a manner well known to those familiar with this art, a pipe elevator **16** with a bowl adapted to receive the drill pipe and containing conventional slips (not shown) to support the drill pipe from the said pipe elevator **16** is suspended from travelling block **3**, the pipe elevator **16** having wheels at both sides thereof riding in channels **2** in the manner shown in U.S. Pat. No. 3,451,493.

Derrickman's platforms **17** and **18**, with a space **19** therebetween, are mounted to derrick **1** at about the midportion thereof. Stabbing finger **20** is slidably mounted to platform **17** and can be extended into or retracted from space **19**. As shown in FIGS. **6** and **7**, stabbing finger **20** is slidably mounted in guideway **21** in platform **17**. The guideway **21** is partially open on top, and projection or handle **22** extending laterally from stabbing finger **20** projects through the top opening of the guideway **21**. The operator extends stabbing finger **20** into space **19** by pushing projection **22** towards the said space **19**, and retracts stabbing finger **20** from space **19** by pushing projection **22** away from space **19** thereby to clear the said space **19**. Stabbing finger **20** has a recess **23** at its free end adapted to receive drill pipe **24**. When stabbing finger **20** has been fully extended into space **19**, recess **23** thereon lies directly in front of the drilling axis of derrick **1**, and when fully retracted, stabbing finger **20** lies to one side of and in front of the drilling axis of derrick **1**, as particularly shown in FIG. **3**.

Support roller **25** is mounted to derrick **1** at the approximate elevation of platforms **17** and **18** to support walkway **26**. Similarly, bumper beam **27** is supported on the other side of derrick **1**.

Support cup **28**, open at the top to receive the bottom end of a stand of drill pipe **24** and closed at the bottom to support said stand, is pivotally mounted between spaced brackets **29** secured to one side of rotary table **7**. The center of support cup **28** lies directly in front of the drilling axis of derrick **1** as shown.

An upper power-operated centering device **30** is hingedly mounted to derrick **1** above the midpoint of the distance between the rotary table **7** and platforms **17** and **18**.

A lower power-operated centering device **31** is hingedly mounted to derrick **1** just above rotary table **7**.

Upper and lower centering devices **30** and **31** can be extended or retracted between a retracted position directly behind the drilling axis of derrick **1** to an extended position directly in front of the drilling axis of derrick **1** and to an intermediate position on or adjacent the drilling axis of derrick **1**.

Each centering device **30** and **31** comprises spaced arms **32** hingedly mounted on shaft **33** to derrick **1**. The free ends of arms **32** support a concave roller **34**. Hydraulic ram **35** is pivotally mounted on shafts **36** and **37** to derrick **1** and arms **32** respectively. Ports on the cylinder of hydraulic ram **35** communicate through piping (not shown) with a source of pressurized hydraulic fluid (not shown) controlled by suitable control valve (not shown) whereby hydraulic ram **35** can be extended or retracted to extend or retract centering devices **30** and **31**.

Horizontal pipe laydown device **38** is similar to the pipe handling device shown in U.S. Pat. No. 3,451,493, and comprises a base **39** wide enough for stability and mounted on skid unit **11**, V-shaped cradle **40**, and parallel links **41** on each side of base **39** and cradle **40**, the said links **41** being pivotally mounted by means of pins **42** to the said base **39** and cradle **40**. Approximately in the center of horizontal pipe laydown device **38**, a hydraulic ram **43** is interposed between and pivotally mounted to base **39** and cradle **40** by means of pins **44**.

Pipe supports 45 are mounted in cradle 40 on rollers 46, whereby the said pipe supports 45 are freely movable in said cradle 40 longitudinally of the horizontal pipe laydown device 38. Ports at either end of the cylinder of hydraulic ram 43 communicate through suitable piping (not shown) with a source of pressurized hydraulic fluid (not shown) controlled by a suitable control valve (not shown) whereby hydraulic ram 43 can be extended or retracted to raise or lower cradle 40.

Means (not shown) to rack pipe to or from horizontal pipe laydown device 38 may be provided at either or both sides thereof.

Vertical pipe racking tower 47 is mounted on skid unit 11 and may be braced by suitable guy wires (not shown). It will be seen from FIG. 14 that the side of tower 47 facing derrick 1 is open and that, at the upper portion of said tower 47, an operating platform 48 is provided with a pipe rest 49 adjacent thereto and with a series of elements 50, likewise adjacent thereto, defining pipe racking bays 51 receiving the upper ends of stands of drill pipe 24. The lower ends of these stands of drill pipe 24, when vertically racked in tower 47, stand on the set back area bounded by the lower portion of the said tower 47. It will be noted, from FIG. 2, that that side of tower 47 remote from derrick 1 has an inverted V-shaped opening at the bottom thereof, whereby said tower 47 straddles horizontal pipe laydown device 38 and permits the passage of drill pipe 24 between the derrick 1 and the said horizontal pipe laydown device 38.

Walkway 26 and bumper beam 27 are each hingedly mounted to vertical pipe racking tower 47 on pivots 47a.

Transfer winch 52 is mounted on or adjacent operating platform 48 of vertical pipe racking tower 47 and operates forked transfer cable system 53 which extends between the upper portions of derrick 1 and the said vertical pipe racking tower 47.

Forked transfer cable system 53 comprises cable 54 running from the drum of transfer winch 52 over roller 55 on vertical pipe racking tower 47 and thence across to derrick 1 and around sheave 56 secured thereto, and back to vertical pipe racking tower 47 and around roller 57 secured thereto, and thence over roller 58 to counterweight 59. Secured to cable 54 at a point 60 between roller 55 and sheave 56 is a length of transfer cable 61, to the bottom of which is secured pipe elevator 62. Pipe elevator 62 is of conventional design adapted to securely grasp or clamp a stand of drill pipe 24 around and under its tool joint or socket, as shown diagrammatically in FIG. 8, to raise or lower said stand of drill pipe 24 as required. It will be apparent from the drawings that, as transfer winch 52 is operated to take up cable 54 on the drum, the transfer cable 61 will move from the derrick 1 toward the vertical pipe racking tower 47, and the counterweight 59 will rise, and continued operation of the transfer winch 52 will ring point 60 on cable 54 over and past roller 55 as particularly shown in FIGS. 13 and 15. It will also be apparent from the drawings that, after the above described operation of transfer winch 52 has been stopped, and the drum of transfer winch 52 released, counterweight 59 will descend and transfer cable 61 will move from the vertical pipe racking tower 47 toward the derrick 1 and this movement may be controlled and stopped at any point by braking and locking the drum of the said transfer winch 52.

Counterweight 59 should have sufficient mass at least to keep cable 54 between sheave 56 and roller 57 taut under all conditions of operation.

The operation of the present invention will now be described.

It will be assumed that the skid unit 11 with derrick 1, horizontal pipe laydown device 38 and vertical pipe racking tower 47 have been placed on location where a well is to be drilled, and that lengths of drill pipe 24 are racked along one or both sides of the horizontal pipe laydown device 38.

When initially making up the string of drill pipe 24, pipe elevator 16 is placed in channels 2 of derrick 1 and suspended from the travelling block 3, in the manner shown and described in U.S. Patent 3,451,493.

With horizontal pipe laydown device 38 in its lowermost position, a length of drill pipe 24 is taken from the racks alongside the device 38 and placed on the pipe supports 45, and the hydraulic ram 43 is pressurized to raise the device 38 and extend it through the inverted V-shaped opening at the bottom of the vertical pipe racking tower 47 and toward the derrick 1 as shown in FIG. 1. Travelling block 3 is lowered thereby to place pipe elevator 16 adjacent the end of the length of drill pipe 24 on horizontal pipe laydown device 38. Pipe elevator 16 is now connected to the end of the length of drill pipe 24, and travelling block 3 is elevated in derrick 1 thereby to carry the length of drill pipe 24 through vertical pipe racking tower 47 and into derrick 1. Lower centering device 31 may be extended, by pressurizing hydraulic ram 35, thereby to engage the lower portion of the length of drill pipe 24 as it approaches derrick 1 so as to guide the said length of drill pipe 24 to a position in which the longitudinal axis thereof registers with the drilling axis of the derrick 1 and rotary table 7. Travelling block 3 is then lowered, thereby to lower the initial length of drill pipe 24 through the rotary table 7 until the tool joint or socket at the top of the length of drill pipe 24 is just above the rotary table 7, whereupon slips (not shown) are set in the rotary table 7, in the manner known to those familiar with this art, whereby to suspend the length of drill pipe 24 from the rotary table 7. Pipe elevator 16 is freed from the top of this suspended length of drill pipe 24 and is connected to the top of another length of drill pipe 24 on horizontal pipe laydown device 38, which other length of drill pipe 24 had, during the foregoing operations, been taken from the racks alongside the horizontal pipe laydown device 38, placed in the pipe supports 45 thereof, and elevated and extended through the vertical pipe racking tower 47 toward derrick 1 by pressurizing hydraulic ram 43. Travelling block 3 is again raised to bring this next length of drill pipe 24 through the vertical pipe racking tower and into derrick 1, assisted by lower centering device 31 to align this next length of drill pipe 24 with the drilling axis of the derrick 1 and rotary table 7 as hereinbefore described. This next length of drill pipe 24 is lowered by travelling block 3 until its bottom contacts the top of the suspended length of drill pipe 24 in the rotary table 7, whereupon the two lengths of drill pipe 24 are made up (i.e., the ends thereof are threaded together). The slips in the rotary table 24 are released, and the travelling block 3 is lowered to lower the connected lengths of drill pipe 24 until the top of the now connected lengths of drill pipe 24 with its tool joint or socket is just above the rotary table 7, whereupon the

slips in the rotary table 7 are again set to hold the connected lengths of drill pipe 24 suspended therein. Pipe elevator 16 is freed from the top of the connected lengths of drill pipe 24 and is connected to yet another length of drill pipe 24 on the horizontal pipe laydown device 38.

The operation hereinbefore described is repeated until a string of drill pipe 24 of the desired length has been made up.

Pipe elevator 16 is now removed from travelling block 3 and derrick 1, and a swivel and kelly are placed in the derrick 1 and suspended from travelling block 3 in the manner shown and described in U.S. Pat. No. 3,451,493, and drilling operations are carried out in the conventional manner.

Now let it be assumed the drill bit which has been placed at the bottom of the string of drill pipe 24 in the known manner has broken or worn so that it must be replaced. In order to reach the drill bit, the string of drill pipe 24 must be removed from the well and broken down into stands and stored.

The swivel and kelly are disconnected from travelling block 3 and removed from derrick 1, and the pipe elevator 16 is inserted in derrick 1 and connected to travelling block 3, all in the manner shown and described in U.S. Pat. No. 3,451,493. Travelling block 3 is then raised to raise the string of drill pipe 24 through rotary table 7 until the joint at which the string of drill pipe 24 is to be broken is just above the rotary table 7, as shown in FIG. 9. The slips in the rotary table 7 are set, and lower centering device 31 is extended to engage the string of drill pipe 24. The joint in the string of drill pipe 24 is now broken (i.e., the threaded joint is unscrewed by the conventional tongs). The lower centering device 31 is now further extended to swing the freed stand of drill pipe 24 out of the derrick so that the bottom end of said stand of drill pipe 24 overlies the pivoted support cup 28, and travelling block 3 is lowered slightly so that the bottom end of said stand of drill pipe 24 enters the pivoted support cup 28 and engages and is supported by the closed bottom thereof, as shown in FIG. 10. The lower centering device 31 is now fully retracted.

The upper centering device 30 is now extended to engage the stand of drill pipe 24 and, when done, the pipe elevator 16 is freed from the upper end of said stand of drill pipe 24. The upper centering device 30 is further extended to push the stand of drill pipe 24 out of the derrick 1 through opening 19 between derrick man's platforms 17 and 18 to clear the line of travel of retracted sliding stabbing finger 20, the stand of drill pipe 24 pivoting in pivoted support cup 28, as shown in FIG. 11.

Sliding stabbing finger 20 is now fully extended into opening 19 so that recess 23 therein lies directly in front of the drilling axis of derrick 1 as shown in FIG. 3. Thereupon, upper centering device 30 is fully retracted so that the upper portion of the stand of drill pipe 24 moves back toward derrick 1 until it engages recess 23 of sliding stabbing finger 20 and is supported thereby, as shown in FIG. 12. At this point, lowering of travelling block 3 is commenced to bring pipe elevator 16 down and adjacent to the top of the string of drill pipe 24 held suspended in rotary table 7 by means of the slips therein, for connection thereto.

Pipe elevator 62 is now connected to the top of the stand of drill pipe 24, as indicated diagrammatically in FIG. 8. Transfer winch 52 is operated to wind up cable 54 on the drum thereof, whereupon transfer cable 61 and pipe elevator 62 are moved from adjacent derrick 1 toward the vertical pipe racking tower 47, during winch operation the stand of drill pipe 24 will pivot about its bottom, which is supported in pivoted support cup 28, toward the said vertical pipe racking tower 47. Continued operation of transfer winch 52 in the foregoing manner will bring point 60 around and past roller 55 toward the drum of transfer winch 52, thereby elevating transfer cable 61, pipe elevator 62 and the stand of drill pipe 24 secured thereto so that the bottom of said stand of drill pipe 24 is lifted completely out of pivoted support cup 28 and swings toward vertical pipe racking tower 47, as shown in FIG. 13. The floor man on skid unit 11 guides the free lower portion of this stand of drill pipe 24 to the setback area on skid unit 11 bounded by vertical pipe racking tower 47, and the racking tower man on operating platform 48 operates transfer winch 52 in a suitable manner to lower the bottom of this stand of drill pipe 24 on to the setback area floor. The top of the stand of drill pipe 24 is placed by the racking tower man on operating platform 48 in pipe rest 49, pipe elevator 62 is disconnected from the top of the stand of drill pipe 24, and the said stand of drill pipe 24 is then positioned in the desired pipe racking bay 51.

The drum of the transfer winch 52 is released and suitably braked as required, so that transfer cable 61 and pipe elevator 62 are, under the influence of the descending counterweight 59, moved from adjacent the vertical pipe racking tower 47 to the desired position adjacent the derrick 1.

In the meanwhile, in the manner hereinbefore described, another length of drill pipe 24 has been disconnected from the string of drill pipe 24 in the well and brought, by manipulation of the upper and lower centering devices 30 and 31 and sliding stabbing finger 20, to the proper position for connection to pipe elevator 62.

The foregoing operation is repeated until the string of drill pipe 24 has been broken into stands and transferred to and racked in the vertical pipe racking tower 47.

Now let it be assumed that it is desired to transfer the stands of drill pipe 24 racked in the vertical pipe racking tower 47 to the derrick 1 and to remake the string of drill pipe 24 in the well.

The racking tower man on operating platform 48 removes the upper portion of a stand of drill pipe 24 from a pipe racking bay 51 and leans the said upper portion of the stand of drill pipe 24 into the pipe rest 49. Transfer winch 52 is operated to wind up cable 54 on the drum thereof to bring transfer cable 61 and pipe elevator 62 adjacent the vertical pipe racking tower 47. Pipe elevator 62 is connected to the upper end of this stand of drill pipe 24, and the transfer winch 52 is operated to bring point 60 around and past roller 55, thereby elevating transfer cable 61, pipe elevator 62 and the stand of drill pipe 24 secured thereto, the bottom end of said stand of drill pipe 24 being lifted off the floor of the setback area as shown in FIG. 15, and the floor man shifts the lower end of the suspended stand of drill pipe 24 over the pivoted support cup 28, and the racking tower man on operating platform 48 operates transfer winch 52 in a suitable manner to lower the bottom end of the stand of drill pipe 24 into the pivoted suport cup 28

until the said stand of drill pipe **24** is supported on the bottom of the pivoted support cup **28.**

Transfer winch **52** is operated in a suitable manner, controlling the weight of the stand of drill pipe **24,** to move transfer cable **61** and pipe elevator **62** toward derrick **1,** the stand of drill pipe **24** secured thereto pivoting at its lower end, which is supported in pivoted support cup **28.** Sliding stabbing finger **20** is fully extended into opening **19,** and the operation of the transfer winch **52** against the weight of counterweight **59** is continued until the upper end of this stand of drill pipe **24** rests in the recess **23** disconnected from the upper end of this stand of drill pipe **24,** and transfer winch **52** is operated to return said transfer cable **61** and pipe elevator **62** to the vertical pipe racking tower **47** for connection to another stand of drill pipe **24,** the upper end of which, in the meanwhile, has been removed from a pipe racking bay **51** and leaned into pipe rest **49.**

The upper centering device **30** is extended to engage the stand of drill pipe **24** supported on the sliding stabbing finger **20** as hereinbefore described and to lift said stand of drill pipe **24** out of recess **23,** whereupon sliding stabbing finger **20** is fully retracted from opening **19.** The upper centering device **30** is now retracted sufficiently to bring the upper end of the stand of drill pipe **24** into the derrick **1** and adjacent pipe elevator **16.** Thereupon, pipe elevator **16** is connected to the upper end of this stand of drill pipe **24,** and the upper centering device **30** is now fully retracted.

The lower centering device **31** is extended to engage and support the lower portion of the stand of drill pipe **24,** and travelling block **3** is raised to lift the bottom end of the stand of drill pipe **24** out of the pivoted support cup **28.** Lower centering device **31** is retracted sufficiently to align the stand of drill pipe **24** with the drilling axis of derrick **1** and rotary table **7,** and the travelling block **3** is now lowered to lower the stand of drill pipe **24** through the rotary table **7** into the well until the tool joint or socket at the top of the stand of drill pipe **24** is just above the top of the rotary table **7,** whereupon the slips in the rotary table **7** are set and thereby suspend the stand of drill pipe **24** therein. Lower centering device **31** is fully retracted, pipe elevator **16** is disconnected from the top of the suspended stand of drill pipe **24,** and travelling block **3** is raised so that pipe elevator **16** may be connected to the next stand of drill pipe **24** which has in the meanwhile been transferred from vertical pipe racking tower **47** to sliding stabbing finger **20.** This next stand of drill pipe **24** is brought into derrick **1** in the manner hereinbefore described, is aligned with the suspended string of drill pipe **24** and lowered to engagement therewith, whereupon the joint between the two sections of drill pipe **24** is made up (i.e., is threaded together using conventional tongs), the slips are removed, and the travelling block **3** lowered to lower the connected sections of drill pipe **24** until the tool joint at the top thereof is just above the top of the rotary table **7,** whereupon the slips are set, the lower centering device **31** is fully retracted and the travelling block **3** raised so that the pipe elevator **16** can be connected to yet another stand of drill pipe **24** transferred from the vertical pipe racking tower **47** to the sliding stabbing finger **20.**

The foregoing operations are repeated until the string of drill pipe **24** is made up from the stands of drill pipe **24** stored in the vertical pipe racking tower **47.**

When it is desired to remove the skid unit **11** from location, the stands of drill pipe **24** resulting from breaking down the string of drill pipe **24** in the well can be transferred through the inverted V-shaped opening at the bottom of the vertical pipe racking tower **47** to the horizontal pipe laydown device **38** and racked alongside the said device **38.**

The invention herein described provides an eminently satisfactory apparatus and method of operation thereof for transferring stands of drill pipe between a slant hole drilling derrick and a vertical pipe racking tower.

We claim:

1. Well drilling apparatus comprising:

a. a derrick having a drilling axis inclined at an angle to the horizontal, the front of said derrick being open to permit the passage of drill pipe laterally into and out of said derrick,

b. a vertical pipe racking tower in front of said derrick and adapted to receive for storage therein vertical stands of drill pipe,

c. first support means adapted to receive the bottom end of and support a stand of drill pipe, said first support means being positioned in front of the derrick adjacent the bottom thereof, said first support means being pivotable in a vertical plane passing through the drilling axis of the derrick and through the vertical pipe racking tower,

d. second support means adapted to engage the side of and laterally support a stand of drill pipe and mounted to the derrick at an elevation above said first support means, said second support means being extendable and retractable between a retracted position behind the drilling axis of the derrick to an extended position in front of the drilling axis of the derrick and to intermediate positions including a position on the drilling axis of said derrick,

e. third support means mounted to said derrick at an elevation above said second support means, said third support means being reciprocable between an operative position directly in front of the drilling axis of the derrick in which operative position said third support means is adapted to engage the side of and laterally support a stand of drill pipe and an inoperative position clear of the front of said drilling axis, the distance between said third support means and said first support means being less than the length of a stand of drill pipe,

f. a first cable extending between the upper portion of said derrick above said third support means and said vertical pipe racking tower,

g. winch means to move said first cable between said derrick and said vertical pipe racking tower,

h. a transfer cable secured at a point of attachment to said first cable and suspended therefrom, said transfer cable being movable between said derrick and said vertical pipe racking tower upon operation of said winch means,

i. pipe transfer means mounted to said transfer cable and adapted to be secured to the upper end of a stand of drill pipe.

2. Well drilling apparatus as in claim **1,** further comprising:

j. counterweight means cooperating with said winch means in the movement of said first cable.

3. Well drilling apparatus as in claim 1, further comprising:
j. said first support means being pivotable in a plane including the drilling axis of said derrick and said first cable.

4. Well drilling apparatus as in claim 1, further comprising:
j. first roller means on said vertical pipe racking tower,
k. a sheave on said derrick,
l. a counterweight,
m. said first cable running from said winch means over said first roller means and thence around said sheave to said counterweight,
n. said point of attachment of said transfer cable to said first cable being movable between a first position adjacent said sheave to a second position between said first roller means and said winch means and to positions between said first and second positions.

5. Well drilling apparatus as in claim 1, further comprising:
j. first roller means on said vertical pipe racking tower,
k. second roller means on said vertical pipe racking tower at an elevation above said first roller means,
l. a sheave on said derrick,
m. a counterweight,
n. said first cable running from said winch means over said first roller means, thence around said sheave and over said second roller means to said counterweight,
o. said point of attachment of said transfer cable to said first cable being movable between a first position adjacent said sheave to a second position between said first roller means and said winch means and to positions between said first and second positions.

6. Well drilling apparatus as in claim 1, further comprising:
j. said vertical pipe racking tower having an opening through the lower portion thereof aligned with said derrick,
k. means on said derrick adapted to transfer through said opening to said derrick drill pipe stored horizontally adjacent that side of said vertical pipe racking tower remote from said derrick.

7. Well drilling apparatus as in claim 1, further comprising:
j. said vertical pipe racking tower having an opening through the lower portion thereof aligned with said derrick,
k. a horizontal pipe handling device extendable through said opening and straddled by said vertical pipe racking tower,
l. means on said derrick adapted to transfer through said opening to said derrick drill pipe stored horizontally on said horizontal pipe handling device.

8. Well drilling apparatus comprising:
a. a derrick having a drilling axis inclined at an angle to the horizontal, the front of said derrick being open to permit the passage of drill pipe laterally into and out of said derrick,
b. a vertical pipe racking tower in front of said derrick and adapted to receive for storage therein vertical stands of drill pipe,
c. first support means adapted to receive the bottom end of and support a stand of drill pipe, said first support means being positioned in front of the derrick adjacent the bottom thereof, said first support means being pivotable in a vertical plane passing through the drilling axis of the derrick and through the vertical pipe racking tower,
d. second support means adapted to engage the side of and laterally support a stand of drill pipe below the center thereof and mounted to the lower portion of the derrick at an elevation above said first support means, said second support means being extendable and retractable between a retracted position behind the drilling axis of said derrick to an extended position in front of the drilling axis of said derrick and to intermediate positions including a position on the drilling axis of said derrick,
e. third support means adapted to engage the side of and laterally support a stand of drill pipe above the center thereof and mounted to the derrick at an elevation above said second support means, said third support means being extendable and retractable between a retracted position behind the drilling axis of said derrick to an extended position in front of the drilling axis of said derrick and to intermediate positions including a position on the drilling axis of said derrick,
f. fourth support means mounted to said derrick at an elevation above said third support means, said fourth support means being reciprocable between an operative position directly in front of the drilling axis of said derrick in which operative position said fourth support means is adapted to engage the side of and laterally support a stand of drill pipe and an inoperative position clear of the front of said drilling axis, the distance between said fourth support means and said first support means being less than the length of a stand of drill pipe,
g. a first cable extending between the upper portion of said derrick above said fourth support means and said vertical pipe racking tower.
h. winch means to move said first cable between said derrick and said vertical pipe racking tower,
i. a transfer cable secured at a point of attachment to said first cable and suspended therefrom, said transfer cable being movable between said derrick and said vertical pipe racking tower upon operation of said winch means,
j. pipe transfer means mounted to said transfer cable and adapted to be secured to the upper end of a stand of drill pipe.

9. Well drilling apparatus as in claim 8, further comprising:
k. counterweight means cooperating with said winch means in the movement of said first cable.

10. Well drilling apparatus as in claim 8, further comprising:
k. said first support means being pivotable in a vertical plane including the drilling axis of said derrick and said first cable.

11. Well drilling apparatus as in claim 8, further comprising:
k. first roller means on said vertical pipe racking tower,
l. a sheave on said derrick,
m. a counterweight,

n. said first cable running from said winch means over said first roller means and thence around said sheave to said counterweight,

o. said point of attachment of said transfer cable to said first cable being movable between a first position adjacent said sheave to a second position between said first roller means and said winch means and to positions between said first and second positions.

12. Well drilling apparatus as in claim **8,** further comprising:

k. first roller means on said vertical pipe racking tower,

l. second roller means on said vertical pipe racking tower at an elevation above said first roller means,

m. a sheave on said derrick,

n. a counterweight,

o. said first cable running from said winch means over said first roller means, thence around said sheave and over said second roller means to said counterweight,

p. said point of attachment of said transfer cable to said first cable being movable between a first position adjacent said sheave and a second position between said first roller means and said winch means and to positions between said first and second positions.

13. Well drilling apparatus as in claim **8,** further comprising:

k. said vertical pipe racking tower having an opening through the lower portion thereof aligned with said derrick,

l. means on said derrick adapted to transfer through said opening to said derrick drill pipe stored horizontally adjacent that side of said vertical pipe racking tower remote from said derrick.

14. Well drilling apparatus as in claim **8,** further comprising:

k. said vertical pipe racking tower having an opening through the lower portion thereof aligned with said derrick,

l. a horizontal pipe handling device extendable through said opening and straddled by said vertical pipe racking tower,

m. means on said derrick adapted to transfer through said opening to said derrick drill pipe stored horizontally on said horizontal pipe handling device.

15. Well drilling apparatus comprising:

a. a derrick having a drilling axis inclined at an angle to the horizontal, the front of said derrick being open to permit the passage of drill pipe laterally into and out of said derrick,

b. a tilted rotary table adjacent the lower portion of said derrick and having a drilling axis which registers with the drilling axis of said derrick,

c. a vertical pipe racking tower in front of said derrick and said rotary table and adapted to receive for storage therein vertical stands of drill pipe,

d. support means adapted to receive the bottom end of and support a stand of drill pipe, said support means being pivotally mounted to that side of said rotary table facing said vertical pipe racking tower, said support means being pivotable in a vertical plane passing through the drilling axis of said derrick and said vertical pipe racking tower,

e. a first support arm pivotally mounted to said derrick adjacent the lower portion thereof and above said rotary table, said first support arm being pivotable in a vertical plane, the free end of said first support arm being adapted to engage the side of and laterally support a stand of drill pipe below the center thereof,

f. first means to extend or selectively retract said first support arm between a retracted position with said free end behind the drilling axis of said derrick and an extended position with said free end in front of the drilling axis of said derrick and to intermediate positions including a position with said free end on the drilling axis of said derrick,

g. a second support arm pivotally mounted to said derrick above said first support arm, said second support arm being pivotable in a vertical plane, the free end of said second support arm being adapted to engage the side of and laterally support a stand of drill pipe above the center thereof,

h. second means to extend or selectively retract said second support arm between a retracted position with the free end behind the drilling axis of said derrick and an extended position with the free end in front of the drilling axis of said derrick and to intermediate positions including a position with the free end on the drilling axis of the derrick,

i. holding means mounted to said derrick above said second support arm, said holding means being reciprocable between an operative position directly in front of the drilling axis of said derrick in which operative position said holding means is adapted to engage the side of and laterally support a stand of drill pipe and an inoperative position clear of the front of said drilling axis, the distance between said holding means and said support means being less than the length of a stand of drill pipe,

j. a transfer winch,

k. a first cable extending between the upper portion of said derrick and said vertical racking tower and movable therebetween by said transfer winch,

l. a transfer cable secured at a point of attachment to said first cable and suspended therefrom and movable between said derrick and said vertical pipe racking tower upon operation of said transfer winch,

m. pipe transfer means mounted to said transfer cable and adapted to be secured to the upper end of a stand of drill pipe.

16. Well drilling apparatus as in claim **15,** further comprising:

n. counterweight cooperating with said transfer winch in the movement of said first cable.

17. Well drilling apparatus as in claim **15,** said support means comprising:

n. a cup having a closed bottom,

o. a pair of spaced brackets, one on each side of said cup, said brackets being mounted to said rotary table,

p. means pivotally mounting said cup between said brackets.

18. Well drilling apparatus as in claim **15,** said holding means comprising:

n. a stabbing finger mounted for reciprocation along a line in front of the drilling axis of said derrick.

19. Well drilling apparatus as in claim **15,** further comprising:

n. first roller means on said vertical pipe racking tower,

o. a sheave on said derrick,

p. a counterweight,

q. said first cable running from said transfer winch over said first roller means and thence around said sheave to said counterweight,

r. said point of attachment of said transfer cable to said first cable being movable between a first position adjacent said sheave and a second position between said first roller means and said transfer winch and to positions between said first and second positions.

20. Well drilling apparatus as in claim **15**, further comprising:

n. first roller means on said vertical pipe racking tower,

o. second roller means on said vertical pipe racking tower at an elevation above said first roller means,

p. a sheave on said derrick,

q. a counterweight,

r. said first cable running from said transfer winch over said first roller means, thence around said sheave and over said second roller means to said counterweight,

s. said point of attachment of said transfer cable to said first cable being movable between a first position adjacent said sheave and a second position between said first roller means and said transfer winch and to positions between said first and second positions.

21. Well drilling apparatus as in claim **15**, further comprising:

n. said vertical pipe racking tower having an opening through the lower portion thereof aligned with said derrick,

o. means on said derrick adapted to transfer through said opening to said derrick drill pipe stored horizontally adjacent that side of said vertical pipe racking tower remote from said derrick.

22. Well drilling apparatus as in claim **15**, further comprising:

n. said vertical pipe racking tower having an opening through the lower portion thereof aligned with said derrick,

o. a horizontal pipe handling device extendable through said opening and straddled by said vertical pipe racking tower,

p. means on said derrick adapted to transfer through said opening to said derrick drill pipe stored horizontally on said horizontal pipe handling device.

23. Method of transferring a stand of drill pipe from a well-drilling derrick having a travelling block, an open front, and a drilling axis inclined at an angle to the horizontal, to a vertical pipe racking tower, said method comprising:

a. supporting the stand of drill pipe on the drilling axis of the derrick while uncoupling the bottom of the stand of drill pipe from the string of drill pipe in the well,

b. applying a force to the side of the stand of drill pipe to swing the lower end of said stand of drill pipe from the drilling axis of the derrick out of the front of the derrick to a station in front of the drilling axis of the derrick, while supporting the upper end of said stand of drill pipe from the travelling block on the drilling axis of the derrick,

c. pivotally supporting the bottom end of said stand of drill pipe at said station for rotation in a vertical plane including the drilling axis of said derrick and said vertical pipe racking tower,

d. laterally supporting the upper end of said stand of drill pipe on the drilling axis of the derrick while uncoupling the travelling block from said upper end,

e. applying a force to the side of the stand of drill pipe to swing the upper end of said strand of drill pipe from the drilling axis of the derrick out of the front of the derrick to a first position in front of the drilling axis of and adjacent the derrick, the said stand of drill pipe pivoting in a vertical plane about its bottom end at said station,

f. engaging the upper end of said stand of drill pipe and swinging it from said first position to a second position at said vertical pipe racking tower, the said stand of drill pipe further pivoting in a vertical plane about its bottom end at said station,

g. while supporting the upper end of said stand of drill pipe at said second position, swinging the bottom end of said stand of drill pipe from said station to said vertical pipe racking tower.

24. Method as in claim **23**, further comprising:

h. performing step (b) by applying a force to the side of the stand of drill pipe below the center thereof,

i. performing step (e) by applying a force to the side of the stand of drill pipe above the center thereof.

25. Method of transferring a stand of drill pipe from a vertical pipe racking tower to a well-drilling derrick having a travelling block, an open front, and a drilling axis inclined at an angle to the horizontal, said method comprising:

a. engaging the upper end of said stand of drill pipe to support the same at said vertical pipe racking tower,

b. swinging the bottom end of said stand of drill pipe from said vertical pipe racking tower to a station in front of the drilling axis of said derrick,

c. pivotally supporting the bottom end of said stand of drill pipe at said station for rotation in a vertical plane including the drilling axis of said derrick and said vertical pipe racking tower,

d. swinging the upper end of said stand of drill pipe from said vertical pipe racking tower to a position in front of the drilling axis and adjacent said derrick, the said stand of drill pipe pivoting in a vertical plane about its bottom end,

e. supporting the side of said stand of drill pipe and then moving the upper end thereof from said position to the drilling axis of said derrick, the said stand of drill pipe further pivoting in a vertical plane about its bottom end at said station,

f. coupling the upper end of said stand of drill pipe to the travelling block,

g. supporting the side of said stand of drill pipe and then moving the lower end thereof from said station to the drilling axis of the derrick.

26. Method as in claim **25**, further comprising:

h. performing step (e) by engaging the side of the stand of drill pipe above the center thereof,

i. performing step (g) by engaging the side of the stand of drill pipe below the center thereof.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,805,902 Dated April 23, 1974

Inventor(s) James C. Storm et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 57, after "transfer winch 52 will" the word "ring" should read "bring".

Column 7, line 16, after "assumed" should be inserted "that".

Column 8, line 5, before "operation" the word "winch" should read "which".

Column 8, line 67, after "pivoted" the word "suport" should read "support".

Column 9, line 12, after "recess 23" should be inserted "of the said sliding stabbing finger 20. Pipe elevator 62 is now".

Column 16, line 12, after "said" the word "strand" should read "stand".

Signed and sealed this 10th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents